CHEMOSTRATIGRAPHY AND FE MINERALOGY OF THE VICTORIA CRATER DUCK BAY SECTION: OPPORTUNITY APXS AND MÖSSBAUER RESULTS. D. W. Mittlefehldt[1] , C. Schröder[1], R. Gellert[2], G. Klingelhöfer[3], B. L. Jolliff[4], R. V. Morris[1] and the Athena Science Team, [1]NASA-Johnson Space Center, USA (david.w.mittlefehldt@nasa.gov), [2]University of Guelph, Canada, [3]Johannes Gutenberg University, Germany, [4]Washington University, USA.

Introduction: Meridiani Planum is a vast plain of approximately horizontally bedded sedimentary rocks composed of mixed and reworked basaltic and evaporitic sands containing secondary, diagenetic minerals [e.g., 1-5]. Because bedding planes are subparallel to topography, investigation of contiguous stratigraphy requires examining exposures in impact craters. Early in the mission (sols 130-317), Opportunity was commanded to do detailed study of exposed outcrops in Endurance crater, including the contiguous Karatepe section at the point of ingress. Just over 1000 sols later and roughly 7 km to the south, the rover is being commanded to do a similar study of the Duck Bay section of Victoria crater. Here we report on the preliminary results from the Alpha Particle X-ray Spectrometer (APXS) and Mössbauer instruments.

Stratigraphy: The stratigraphy of Duck Bay was defined based on decorrelation-stretched false-color Panoramic Camera images that showed variation within a bright layer that forms a more-or-less continuous "bathtub ring" below an ejecta layer at the crater rim. The "bathtub ring" can be followed along the whole crater rim. At the Duck Bay ingress location, three stratigraphic units have been defined; Steno, Smith and Lyell (Figure 1). Steno is light-toned and has topographic relief expressed locally. Below Steno is the light-toned Smith unit which exhibits fine-scale lamina. In areas where relief is absent in Steno, its contact with Smith is indistinct. Lyell is a darker unit with coarser laminae. The contact with overlying Smith is distinct. APXS and Mössbauer analyses have been done on all three units, including natural and brushed surfaces, and rock interiors exposed by the Rock Abrasion Tool (RAT).

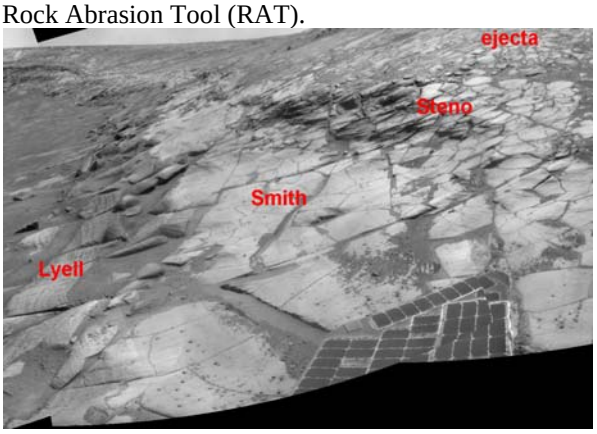

Figure 1. A portion of the sol 1382 Navigation Camera mosaic showing the upper stratigraphy of the Duck Bay section, Victoria crater.

APXS Results: Meridiani bedrock possibly differentially weathers, may have chemical coatings, and invariably has some surface contamination of air-fall dust and/or saltating sands [3]. Because of this, natural and brushed surfaces may not faithfully record the compositions of the underlying rock. Here, we will concentrate on APXS measurements made on holes ground by the RAT. One RAT hole each has been done on the three units - the targets Steno, Smith2 and Lyell1.

The compositions of rocks in Duck Bay fall within the range of data for Meridiani Planum rocks in general with one exception; Zn in Smith2 is 24% higher than in any other rock. There are variations in major element chemistry with depth in the section (Fig. 2). Compared to Steno, Smith2 has a higher silicate component, expressed by higher Al and Si, a concomitant decrease in sulfate component, a 23% increase in Cl and a 20% decrease in Ca. Lyell1 is also enriched in a silicate component and depleted in a sulfate component compared to Steno, but less so than is Smith2. Calcium is depleted in Lyell1 compared to Steno. The major distinction of Lyell1 is the more than a factor-of-two increase in Cl. In this, Lyell1 is similar to outcrops encountered lower in the section in Endurance crater [3].

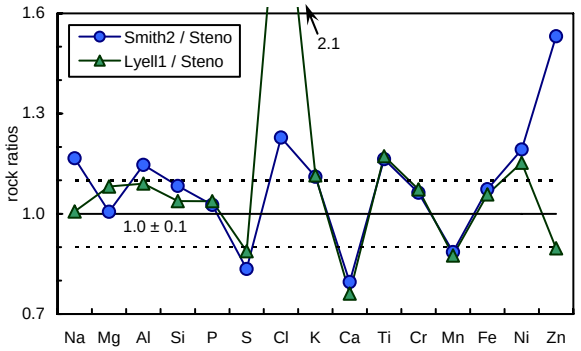

Figure 2. Target ratios by element for abraded rocks in Victoria crater. Dashed lines show ±10% deviations from the Steno composition.

Mössbauer Results: Mössbauer spectra were obtained from a natural surface of Steno, natural surface and RAT hole of Smith2, and RAT hole Lyell1. All

spectra show (in order of decreasing abundance) hematite, jarosite, an undefined ferric doublet Fe3D3, pyroxene, and minor or no olivine. The Fe mineral contents fall within the typical range of outcrops observed between the landing site in Eagle Crater and Victoria. Previous paired measurements of natural surfaces and RAT holes of targets have shown that the olivine component is lower in the abraded targets and therefore is probably part of an altered surface coating. The effect is small, but the lack of a measurement on an abraded target on the Steno layer somewhat compromises the data set. In the Karatepe section only RAT-abraded targets were measured [6]. There was no apparent systematic trend in the Fe mineralogy in the Karatepe section, although there are slight variations between layers [6]. Comparing Steno (natural), Smith2 (RAT), and Lyell1 (RAT), Steno has highest olivine, >4 % compared to < 2% in the other targets, reflecting its undisturbed status. Lyell appears to have the highest pyroxene content of the three, followed by Steno.

Discussion: Here we will compare stratigraphic variations in the Duck Bay section with those of the Karatepe section in Endurance crater, and Duck Bay rocks with Meridiani outcrops in general.

Several systematic chemical variations with stratigraphic depth were noted for the Karatepe section [3]. In particular, S and Mg systematically decrease with depth, while Si increases. The probable cause for this is a systematically varying ratio of sulfate to siliciclastic components. Chlorine variations are discontinuous. In the topmost section, Cl is 0.6-0.7 wt%; typical values for Meridiani Planum outcrops. Lower in the section, Cl contents jump to values more than two times higher – 1.4-2.0 wt% – concentrations that are anomalous among Meridiani Planum rocks.

The Duck Bay section shows some of the Karatepe characteristics, but with only limited depth sampled so far, it is premature to ascribe differences with depth to systematic variations. The S contents of Smith2 and Lyell1 are lower than that of Steno, mimicking the Karatepe trend. However, Mg in Smith2 is roughly the same as in Steno, while in Lyell1 Mg is higher. This is in contrast to the generally decreasing content with depth observed for Karatepe. (Note that the topmost rock target of the Karatepe section has lower Mg than the next unit down, but excluding this topmost unit, Mg generally decreases with depth in Endurance crater.) Silicon again mimics the Karatepe trend, with higher Si contents in Smith2 and Lyell1 compared to Steno. Chlorine is discontinuous in the Duck Bay section as it is in the Karatepe section. The Cl contents Steno and Smith2 are 0.7 and 0.8 wt%, within the range of typical Meridiani rocks, while in Lyell1 Cl is 1.4 wt%. It remains to be seen if rocks deeper in the section continue the trend of Cl-enrichment relative to layers higher in the stratigraphy as observed in the Karatepe section.

The sediments in Meridiani Planum are suggested to have been derived from muds from an evaporating playa lake [5]. The muds were composed of siliciclastic alteration materials and evaporite minerals derived from a basaltic source. Upon desiccation, sand-sized dried mud particles were transported by wind to the site of deposition forming the framework of the Meridiani rocks. Thus, concomitant variations in the ratio of sulfate to siliciclastic material with stratigraphic depth could reflect systematic variation in the nature of the aeolian grains being deposited with time. However, post-depositional diagenesis occurred in these sediments [5], and mobilization of sulfates by this process might also explain the trend.

The high Cl contents observed in Lyell1 and the lower Karatepe section are anomalous. With one exception, Cl-rich rocks have only been found at depth in recent craters. This suggests three possible explanations; (i) we sampled the same subsurface stratigraphic unit in Endurance and Victoria craters, (ii) the high Cl was engendered by late diagenetic processes, and we have found the boundary of the process at both craters, or (iii) all Meridiani rocks were originally Cl-rich, but the current environment is mobilizing Cl out of near-surface rocks. The latter seems unlikely as brushing and abrading Meridiani rock with typical Cl contents lowers the Cl, indicating that Cl-rich coatings form on the rocks when they are exposed to the current environment [7].

As mentioned, we have analyzed a single Cl-rich rock from the plains – LemonRind from the Olympia area roughly midway between Endurance and Victoria craters [7]. The analyzed target is a differently colored (in false color images) rind on typical Meridiani rock. The morphology suggests that it may be a alteration selvage, or crack filling added to the rock after deposition, possibly indicating fluid migration. Thus, this rock gives some evidence that high Cl contents may be a result of later diagenesis, rather than initial deposition.

References: [1] Squyres S.W. et al. (2004) Science, 306, 1698. [2] Squyres S.W. et al. (2004) Science, 306, 1709. [3] Clark B.C. et al. (2005) Earth Planet. Sci. Let., 240, 73. [4] Grotzinger J.P. (2005) Earth Planet. Sci. Let., 240, 11. [5] McLennan S.M. (2005) Earth Planet. Sci. Let., 240, 95. [6] Morris R.V. (2006) JGR, 111, E12S15, doi :10.1029/2006-JE002791. [7] Knoll et al. (2008) *JGR Planets*, in press.